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Levels of Acrylamide in Commercial Potato Crisps Sold in Nairobi County, Kenya

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Abstract Acrylamide is mainly formed in fried and baked carbohydrate rich foodstuffs such as potato chips and crisps through maillard reaction at elevated temperatures. This study was designed to determine the levels of acrylamide in commercial potato crisps those sold in Nairobi, Kenya. Different brands of potato crisps were purchased from retail outlets while unbranded (street) samples were purchased from kiosks in five districts of Nairobi County. The samples purchased were a total of 35 branded samples and 15 unbranded samples. The parameters analyzed were moisture, colour and acrylamide content. The moisture content of the crisps ranged from 0.39% to 7.97%. There was a significant ($P \leq 0.05$) difference among the crisp samples in the L* a* b* colour parameters. Most of the samples were light colored with lightness (L*) parameters greater than 50 apart from only two samples. Most samples tended towards green as shown by the negative values of redness parameter (a*) indicating that there was less or no excess browning of the products during frying. All the samples tended towards yellow as indicated by positive values of yellowness parameter (b*). Acrylamide levels significantly ($P \leq 0.05$) differed between the traded crisps brands ranging from non-detectable levels to 8666 µg kg−1 in the branded samples while in the unbranded samples it ranged from 5666 µg kg−1 in Kiosk 7 to 9499 µg kg−1 in Kiosk 6. There was a significant difference ($P<0.05$) in acrylamide levels between the branded and the unbranded (street) potato crisps. Most of the flavoured brands were non-detectable.

Keywords: *acrylamide, potato crisps, carcinogen, colour, processing*

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1. Introduction

Potatoes (*Solanum tuberosum)* are high in carbohydrate and vitamin C, and are perceived by consumers as an important component of a healthy balanced diet. With a yearly worldwide production of approximately 330 million tons, the potato represents one of the world's major staple food crops. Globally, potato is the fourth most widely grown food crop after rice, wheat and maize [1]. Potato comes second as the most valuable cash and food crop after the cereal grains in Kenya according to the Ministry of Agriculture [2]. Potato crisps and French fries are the most consumed potato products [3,4]. According to the East African Standards [5] and Salvador and others [6], a potato crisp is defined as a fragile but firm slice of potato which has been cooked by deep frying in vegetable oil and to which edible salt (powder or brine) or permitted food grade spices, colour and flavour may have been added. Acrylamide has been classified as a Group 2A carcinogen by the International Agency for Research on Cancer [7] and remains a suspected human carcinogen and a neurotoxicant that calls for a concerted effort to minimize its presence in all human diets [8,9,10]. Acrylamide is mainly formed in fried and baked carbohydrate-rich foodstuffs such as potatoes as its formation pathway is linked with the reaction involving sugars and free amino acids at elevated temperature.

The estimated exposure to acrylamide has been shown to depend on dietary habits of consumers in different countries [11]. Consumption patterns vary among people of different ages, and younger people for instance, tend to eat more snacks than older people [12], which may result in a higher intake of acrylamide among the younger generation and hence higher potential risk of developing cancer related disorders. The consumption pattern is similar in Kenya and has been on the increase [13]. Crisps processed from potatoes have tremendously gained popularity especially in major towns in Kenya [13]. Most city dwellers consume potato crisps as snack between meals and during festivities [13]. The acrylamide content in fried potato products can be related to colour [14] and hence the need to monitor color parameters of acrylamide prone products such as potato crisps . Colour is also an important quality parameter that determines the acceptance of fried potato products. Since there is limited data on acrylamide content in potato crisps in the Kenyan

market, this study aimed at evaluating the levels of acrylamide in commercial crisps in the Kenyan market and determining the relationship between color and acrylamide formation. The conditions of growing potatoes as well as post-harvest handling and processing in Kenya also vary in comparison to other countries where data is readily available. In addition, the comparison of the acrylamide content in branded and in the unbranded potato crisps was done. The acquired information was useful in determining the level of exposure to acrylamide potato crisps consumers.

2. Materials and Methods

2.1. Survey of Acrylamide Contents in Potato Crisps

2.1.1. Study Site

The study was carried out in Nairobi County, Kenya. Nairobi is the capital city of Kenya and has eight constituencies: Makadara, Embakasi, Starehe, Langata, Kasarani, Westlands, Kamukunji and Dagorreti. The main administrative divisions are Kibera, Makadara, Westlands, Central, Dagorretti, Embakasi, Kasarani and Pumwani. According to the 2009 census the population is estimated to be 3,138,295 with a total area of 696 km2. It is a cosmopolitan and multicultural city. Half of the population lives in slums, while most of the up market suburbs are situated to the west and north central of Nairobi, Lower middle and upper middle income located in the north central areas while low and lower income estates are situated in eastern parts. Most of the food production industries are located in the industrial area.

2.1.2. Study Type and Design

This study was carried out in Nairobi city and its environs. Nairobi was purposively selected due to the large number of factories and outlets that process crisps [13]. The study was a cross-sectional survey and applying quantitative data collection methods through laboratory analysis.

2.1.3. Sample Size Determination

Sampling frame was obtained in which number of retail outlets dealing in potato crisps was established. The total number obtained from the listings was found to be 140 supermarkets [15] in Nairobi, from this, 30 outlets was randomly selected. Also from the five districts selected a total of thirty samples were purchased from the roadside kiosks.

2.1.4. Sampling Procedure

This study employed purposive sampling and simple random sampling techniques. Nairobi comprises nine districts. Five districts was purposively selected which include: Starehe, Embakasi, Westlands, Kasarani and Langata. About 30 supermarkets were purposively selected which stock various brands of crisps. From Starehe 10 supermarkets were selected purposively while five from each of the remaining four districts. A total of 35 samples of branded crisps each weighing 50g were randomly picked from the supermarkets in duplicates and 8 flavored samples in duplicates . Three Vendors from each of the five districts were purposively selected. For the unbranded crisps three samples were purchased randomly from each of the five regions in duplicates. Data was collected on type of outlet and their locations, brands, moisture, color and acrylamide contents.

2.2. Techniques of Data Collection

This involved quantitative data collection through laboratory analysis of the commercial potato crisps purchased.

2.2.1. Analytical Methods.

2.2.1.1. Determination of Moisture Content

The moisture content of the potato crisps was determined by oven drying according to AOAC [16]. The oven used was of model DS0-500D made in Israel.

2.2.1.2. Determination of Color of Crisps

The colours of the potato crisps were evaluated using a color spectrophotometer as described by Abong' et al.[17]. The potato crisps color was measured with a color spectrophotometer NF 333 (Nippon Denshoku, Japan) using the CIE Lab L*, a* and b* color scale. The 'L*' value which is the lightness parameter indicating degree of lightness of the sample varies from 0=black to 100=white. The 'a*' is the chromatic redness parameter whose value means tending to red color when positive (+) and green color when negative (–). The 'b*' is yellowness chromatic parameter corresponding to yellow color when it is positive (+) and blue color when it is negative (–). Each sample was measured for six times.

2.2.1.3. Determination of Acrylamide

Levels of acrylamide were determined as described by the United States Food and Drug Administration (FDA) method Detection and Quantitation of Acrylamide in Foods [18] using a Gas chromatography and Flame ionizable detector (G-14B,Shimadzu, Japan).

Acrylamide extraction

The samples were crushed and 1g was combined with 10 ml of 0.1% formic acid solution and the mixture was then mixed on a test tube shaker (KS250, Japan) for 5 minutes at 300 rpm. The samples were then centrifuged at 3000 rpm for 10 min to ensure easier removal of the oily top layer and ensure further solubility of the acrylamide compound. The supernatant was extracted then filtered using a filter paper (Wattman paper no. 47) before being passed through a 0.45µm nylon syringe filter to remove any suspended particles and then stored in a refrigerator awaiting the cleanup and analysis stage.

Clean up stage

Clean up involved passing the filtered sample through a solid phase extractor tube (Carboprep tm 200 SPE tube, 6ml, 500mg) which was first activated by passing 2 ml of acetone solvent and then 2 ml of 0.1% formic acid. The filtered sample solution was then passed through the tube and allowed to flow under gravity. Water (1 ml) was then fast passed through the tube. The SPE tube was then dried in a vacuum for one minute after which 2 ml of analytical grade acetone flowing through gravity was passed for elution. 1 microliter of the elute was injected into the

column and the chromatogram interpreted. The elute was stored immediately in the refrigerator ready for the GC-FID analysis.

Gas chromatography conditions

The column used was a supelcowax capillary column since it gave good results during determination of the suitable condition for analysis using this column. The injection temperature was maintained at 260°C while nitrogen, the carrier gas, was supplied at 100 bars pressure. The linear velocity of the carrier gas was maintained at 62cm/sec at 100°C, while the oven temperature was set at 100°C then held for 0.5 min before it was allowed to increase at a rate of 15 °C/min to attain a final temperature of 200°C. The limit of detection for the GC-FID was found to be 4.5ppm while the Limit of quantification was 45ppm.

2.3. Data Analysis

Both descriptive and inferential statistical tests including analysis of variance (ANOVA) and least significant difference test (LSD) for the variables were carried out using the Statistical Analysis System (SAS) version 9.1.3. Pearson correlation analysis and multiple regression analysis were also performed to determine relationships between acrylamide and moisture and acrylamide and colour parameters. Where the differences of $p < 0.05$ existed, the samples were considered to be significant.

3. Results and Discussion

3.1. Results

3.1.1. Percentage Moisture Content of Potato Crisps sold in Nairobi, Kenya.

The percentage moisture content in branded samples varied significantly among all the samples $p<0.05$ ranging from 0.39 in crisps 16 to 7.05% in BC21. In the unbranded samples the moisture content ranged from 2.93% from vendor 5 to 6.09% from Vendor 3.

Table 3.1. Percentage Moisture content of potato crisps sold in Nairobi, Kenya

Brand	Moisture content %	Brand	Moisture content %
BC1	3.10±0.0ijklm	BC19	4.07±0.18defghij
BC1 flavoured	4.034±0.35defgh	Vendor 7	2.92±0.25jklmn
BC2	3.03±0.67jklmno	Vendor 8	2.96±0.09ijklmn
BC3 flavoured	5.27±0.02bcd	Vendor 9	3.18±0.09hijklm
BC3	3.89±0.10efghijk	BC20	1.0±0.23qrs
BC4	3.89±0.10efghijk	BC21	7.05±1.3a
BC5	1.64±0.37opqrs	BC22	2.43BC19±0.6mnop
BC5 flavoured	2.91±0.73jklmn	BC23	3.78±0.32ghijkl
Vendor 1	4.88±0.19cdef	BC24	2.48±0.53lmnop
Vendor 2	5.16±0.57bcde	BC25	4.13±0.01defghij
Vendor 3	6.09±0.05abc	BC26	0.88±0.0rs
Vendor 4	5.98±0.70abc	BC27	3.87±0.16efghijk
Vendor 5	4.97±0.37cdef	BC28	4.18±0.314efghi
Vendor 6	4.99±0.10cde	BC29	1.58±0.31opqrs
BC6	2.98±0.11ijklmn	Vendor 10	2.93±0.70jklmn
BC7	3.29±0.01hijklm	Vendor 11	3.16±1.12hijklm
BC8	5.37±0.11bcd	Vendor 12	3.3±0.08hijklm
BC9	3.85±0.24efghijk	BC30	3.97±0.18efghijk
BC10	3.62±0.03ghijkl	BC31	0.99±0.155qrs
BC11	5.19±0.01bcde	BC31 flavoured	3.1±1.2ijklm
BC12	1.71±0.18nopqrs	BC32	4.13±0.01defghij
BC13	4.73±0.21cdef	BC33	1.62±0.20opqrs
BC14	4.29±0.35defghi	BC33 flavoured	3.37±0.31hijklm
BC15 flavoured	1.07±0.21qrs	Vendor 13	5.05±0.06bcde
BC15	0.39±0.10s	Vendor 14	4.50±0.05defgh
BC16	0.67±0.07rs	Vendor 15	5.24±0.04bcd
BC17 flavoured	1.22±0.07pqrs	BC 34 flavoured	4.48±0.05defgh
BC17	0.97±0.21qrs	BC34	2.04±0.03mnopq
BC18	4.47±0.18defgh	BC35	4.26±1.0hijklm

[1]Values are means of two determinants ± standard deviations.

[2]Values with the same letters in the column are not significantly different $p<0.05$.

3.1.2.The Colour Parameters of Different Brands of Crisps Sold in Nairobi, Kenya

All the brands purchased were light colored with L*>50 apart from that of BC21; the lightest brand was BC12 with a lightness level of 77.2. The least yellow was BC4 while the highest value of yellowness parameter was the unbranded sample obtained from BC1 (b*=35.3). Most of the samples tended towards green as the redness parameter veered towards the negative indicating low degree of browning. Most flavoured samples had high values of the redness parameter compared to the other branded samples. The positive value of the yellowness parameter b* is an indication that all the potato crisps in the Kenyan market tend towards yellow.

Table 3.2. Colour of potato crisps sold in Nairobi, Kenya.

Brand	L*	a*	b*
BC1	67.2±3.6cde	7.3±1.2c	35.3±2.3a
BC1 flavoured	67.7±4.7cde	-3.2±1.9stu	30.0±5.9bcdefgh
BC2	62.2±7.7efghijk	-1.7±1.2nopqrst	24.8±3.3mnopqrs
BC3 flavoured	57.4±6.6ijklmop	12.4±3.8a	30.9±2.8bcdef
BC3	59.9±7.8hijklmn	0.9±2.8hijklm	30.6±5.2bcdefg
BC4	67.1±7.2cdef	-3.2±1.4rstu	17.4±2.5x
BC5 flavoured	53.7±9.2op	10.1±5.2ab	25.7±lmnopqr
BC5	62.3±3.5efghijk	-1.69±1.1nopqrst	29.±3.9defghij
Vendor 1	54.7±6.9nop	2.5±3.1efghij	25.6±4.2lmnopqr
Vendor 2	59.6±4.6ijklmno	2.1±3.9efghijk	26.2±5.5klmnop
Vendor 3	52.3±2.9pq	0.9±1.4hijklm	25.7±3.1lmnopqr
Vendor 4	63.2±4.7efghij	7.0±5.7cd	33.3±3.6ab
Vendor 5	59.9±9.1hijklmn	4.4±3.6def	31.5±3.9abcd
Vendor 6	59.2±3.3ijklmno	3.3±1.6efgh	32.3±3.8abc
BC6	67.4±4.0cde	0.7±1.5hijklm	25.4±4.4mnopqrs
BC7	58.5±5.9hijklmno	1.9±1.4ghijk	21.4±9.4tuvwx
BC8	54.0±6.5nop	0.6±2.1ijklmn	21.6±4.4qrstuv
BC9	66.6±4.4cdefg	-2.6±0.5qrstu	28.2±1.1ghijklmn
BC10	63.9±5.8defgh	-3.1±0.7rstu	24.2±4.6nopqrst
BC11	70.1±3.2bc	-3.7±0.6ut	28.2±2.9fghijklm
BC12	77.±2.2a	-3.0±0.3rstu	25.1±1.7mnopqrs
BC13	69.7±4.5cd	0.3jklmno	26.0±jklmnop
BC14	61.8±6.7efghijk	-0.6±3.5mnopqr	31.2±2.0abcdef
BC15	59.8±5.4hijklmn	-2.4±0.53qrstu	24.3±3.3nopqrst
BC15 flavoured	54.2±3.0nop	4.6±1.7de	23.1±3.8opqrstu
BC16	75.9±2.4ab	-2.6±0.5qrstu	21.5±1.4rstuvw
BC17 flavoured	53.7±3.0op	10.7±2.7ab	29.6±3.8defghij
BC17	62.3±5.2efghijk	-0.5±0.5mnopqr	30±3.3defghi
BC18	63.0±6.1efghij	0.2±2.4jklmnop	27.2±2.4hijklmno
BC19	57.3±6.3ijklmnop	0.5±0.5ijklmn	19.7±2.9vwx
Vendor 7	56.6±5.9lkmnop	0.8±4.7hijklm	26.4±4.0jklmnop
Vendor 8	56.5±6.0klmnop	-1.1±2.1nopqrst	22.3±3.1pqrstuv
Vendor 9	55.6±5.5lmnop	0.2±2.2jklmnop	24.0±5.5nopqrst
BC20	70.7±4.4bc	-1.5±0.5nopqrst	28.2±1.5ghijklmn
BC21	47.1±3.8q	4.0±1.4efg	20.4±1.3uvwxt
BC22	59.9±4.4hijklmn	-1.7±2.2nopqrst	25.8±2.5klmnopq
BC23	59.6±6.6hijklmno	0.9±1.7hijklm	20.2±4.0uvwx
BC24	63.2±3.1efghi	-1.7±0.8nopqrst	24.4±1.6nopqrst
BC25	56.9±6.7klmnop	1.4±4.4ghijkl	31.1±3.3bcdef
BC26	72.1±3.9abc	-4.7±0.2u	18.3±1.1wx
BC27	64.0±2.3defgh	0.8±1.3hijklm	21.7±2.8qrstuv
BC28	59.1±7.5ijklmno	-2.1±1.7opqrstu	27.3±2.3hijklmn
BC29	62.2±3.0efghijk	-1.7±0.5nopqrst	28.6±1.5hijklm
Vendor 10	55.1±3.2mnop	1.9±3.6efghijk	26.3±5.6jklmnop
Vendor 11	56.4±6.0lmnop	2.3±2.5efghij	27.2±4.3hijklmno
Vendor 12	51.5±4.3qp	2.4±1.6efghij	25.5±2.3mnopqrs
BC30	55.3l±7.0mnop	0.6±1.1hijklm	26.9±2.0ijklmno
BC31	66.6±6.1cdefg	-1.5±3.8nopqrst	26.6±4.9jklmnop
BC31 flavoured	54.2±6.4nop	8.3±2.2bc	19.1±2.6vwx
BC32	67.7±5.8cde	-2.1±2.6opqrstu	30.6±6.2bcdefg
BC33	60.9±5.0ghijklm	-3.7±1.2ut	20.2±1.9uvwx
BC33 flavoured	56.4±2.1klmnop	4.0±1.8efg	23.1±2.6opqrstu
Vendor 13	54.6±2.6nop	-0.1±0.8klmnopq	31.8±3.1abc
Vendor 14	60.8±4.7ghijklm	-1.2±1.2nopqrst	31.4±5.0abcde
Vendor 15	61.2±3.5fghijkl	-2.2±1.6opqrstu	31.9±4.5abc
BC34 flavoured	59.6±4.0ijklmno	4.2±2.3ef	25.3±2.3mnopqrs
BC34	57.2±4.3jklmnop	-2.4±1.1opqrstu	24.6±3.8nopqrst
BC35	55.0±4.8 mnop	2.8±4.1efgh	29.1±3.7defghijk

[1]Values are means of six determinations ± standard deviation.
[2]The values with similar letters in the same column are not significantly different at 5% level of significance.
BC: Branded Crisps.

3.1.3. Acrylamide Levels of Potato Crisps Sold in Nairobi

The acrylamide levels significantly differed among the brands and place of purchase ranging from non-detectable levels to 8666 µg kg−1 in BC18 for the retail samples while in the unbranded (street) samples the levels ranged from 5666 µg kg−1 in Vendor 7 to 9499 µg kg−1 in Vendor 6. The levels were significantly higher in street samples compared to retail samples. All the flavoured samples, the acrylamide levels were non-detectable.

Table 3.3. Acrylamide levels of potato crisps sold in Nairobi.

Brand	Acrylamide µg/kg	Brand	Acrylamide µg/kg
BC1	6934.4±160defghijk	Vendor 8	6156±1441hijklm
BC1flavoured	ND	Vendor 9	7797±322bcdefgh
BC2	7753±489bcdefh	BC18	8667±377abcd
BC3	3939±321opqr	BC19	7883±559abcdefgh
BC3 flavoured	ND	BC20	1986±89st
BC 4	2776±208qrst	BC21	8417±33abcdefg
Vendor 1	8556.8±1986abcdef	BC22	3834±94nopqrs
Vendor 2	8959.1±311abc	BC23	6605±518fghijkl
Vendor 3	8711.6±298abcd	BC24	3192±205nopqrs
BC5	2895±85qrst	BC25	7739±543bcdegh
BC5 Flavoured	ND	BC26	ND
Vendor 4	9449.3±199ab	BC27	4876±649lmnop
Vendor 5	8739.1±108abcd	BC28	2727±972qrst
Vendor 6	9728.1±276a	BC29	3903±534nopqr
BC6	5311±391klmn	Vendor 10	6678±1489fghijkl
BC7	7317.6±1503cdefgi	Vendor 11	7811±737bcdefgh
BC8	3855±9nopqrs	Vendor 12	8499±448abcdef
BC9	4342±52mnopq	Vendor 30	7497±690bcdefgh
BC10	3076±701opqrst	BC31	4995±470lmno
BC11	6721±823fghijkl	BC31 Flavoured	ND
BC12	2380±241rst	BC32	4267±1313nopq
BC13	8608.8±267abcde	BC33	ND
BC14	8010.5±477abcdefg	BC33 flavoured	2558±320qrst
BC15	ND	Vendor 13	5225±922klmn
BC15 flavoured	ND	Vendor 14	7785±221bcdefgh
BC16	1506±382st	Vendor 15	6746±867defghijk
BC17	5606±444klmn	BC34	5312±344klmn
BC17 flavoured	5151±269klmn	BC34 flavoured	ND
Vendor 7	5666±286hijklm	BC35	2138±78rst

[1]Values are means of two determinants ± standard deviations.
[2]Values with the same letters in the column are not significantly different p<0.05.

3.1.4. Pearson Correlation (r) between Acrylamide Content, Moisture Content and Colour Parameters for Potato Crisps Commercially Available in Nairobi, Kenya

There is a weak positive relationship between the acrylamide contents and the moisture content where r=0.36942. At the same time there exists a very weak positive relationship between the degree of redness and the acrylamide content r=0.1889. This finding agrees with what has been reported by other authors [14]. No relationship between the degree of lightness and the acrylamide content was, however found to exist.

Table 3.4. Pearson correlation (r) between acrylamide content, moisture content and colour parameters for potato crisps commercially available in Nairobi, Kenya

Parameters	Acrylamide	Moisture
Acrylamide	1.000	0.369**
Moisture	0.369**	1.000
L*	-0.089a	-0.313*
a*	0.189a	0.163a
b*	0.334*	0.048a

(n=86); a not significantly different at p>0.05
*Significantly different at p<0.05
** Significantly different at p<0.001

3.2. Discussion

Percentage moisture content in the samples ranged from 0.39 to 7.53 which were slightly higher than those reported by Abong et al., [19]. This is due to the increase in the number of brands available in the market as they have increased from 25 reported to 38 by Abong et al. [17]. The EAS [5] recommends maximum crisps moisture of 5%. In this study, 99% of the branded samples had the recommended moisture content. Thus the crisps in this study can be categorized as shelf life stable. However, the most of the samples (80 %) purchased from the kiosks, had moisture content higher than the maximum recommended levels. These products may therefore not be shelf-stable as moisture influences shelf-life of products. High moisture content can be related to the type of packaging such as polythene bags that have been tampered with thus allowing water percolation into the crisps and also inadequate drying before frying.

Excessive browning of the food products increases at higher temperatures, the acrylamide compound is broken down to glycidamide thus its concentration reduces hence the weak positive relationship between the degree of redness and the acrylamide content. The reducing sugar

content of potatoes can be considered the limiting factor for the potential of acrylamide formation. This is because the level of asparagine in raw potatoes varies only within a narrow range, whereas the reducing sugar content can vary widely depending on variety, maturity, and storage among other growing and processing conditions. State of maturity and storage conditions influence sugars levels and hence directly affect the amount of acrylamide present in fried potato products [19,20,21]. The high concentration of the acrylamide in the commercial Kenyan potato crisps can be related to high reducing sugars in the raw tubers and high frying temperatures. BC23 not only had the lowest value of L* but also the highest a* value, an indication that the crisps were produced from tubers with higher reducing sugars probably greater than 0.25% which is the limit required for processing. Colour and taste development in potato crisps has been known to be influenced by the Maillard reaction between amino acids and reducing sugars [14,22]. Significant differences ($P<0.05$) were noted between different brands in all the color parameters indicating variation in handling and processing conditions of Kenyan potato crisps.

In potato crisps, moisture of the whole product is normally lowered to levels below 2·5 % which is important for the desired textural properties and prolonged shelf life. When the moisture content is lowered below these levels, the core temperature rise above 120°C, acrylamide is thereby formed throughout the product resulting in higher contents [23].

Pre-treatments before frying decreases the acrylamide content as can be seen in the branded samples of BC33 which are seasoned before frying; BC18 have only about 42% potato content, the rest comprising wheat, starch and flours (potato, corn, and rice) mixed with vegetable oils and an emulsifier..

The formation of acrylamide mainly occurs in plant based food stuffs through an irreversible combination of reducing sugars and amino acid mainly asparagine the maillard reaction. Its acrylamide formation begins at 120°C and optimal development occurs between 160°C and 180°C [24]. The use of low frying temperature (under 160°C) reduces the concentration of acrylamide produced but this negatively affect the quality characteristics of the product like texture, color and oil content and consequently the acceptability of the product by the consumer may be reduced. Higher values of acrylamide are an indication of higher level of exposure to this potential carcinogen, neurotoxic and genotoxic substance. The average dietary exposure to acrylamide for children was found to be about two times higher than that for adults in European populations [25]. This could be similar to that in Kenya since young people tend to consume higher amount of this snack [13] due to their lower body weight and high caloric demand. Levels of acrylamide in the flavoured potato crisps were non-detectable and thus need to do more studies to determine the effect of flavouring compounds on acrylamide detection. Taubert et al. [23] found that acrylamide levels increase with greater temperature and cooking time in potatoes with low surface-to-volume ratios (SVR), whereas for potatoes with high surface-to-volume ratios acrylamide levels peak and then decline with further heating. Variation may be a function of the availability of substrate since in low SVR potatoes, there is a larger, steady supply of sugars and asparagine, but in high SVR potatoes, the supply is more quickly depleted. Maximum limits for acrylamide in food have, however, not been established. The WHO guideline for acrylamide in drinking water is 0.5µg/kg but similar information is lacking for foodstuffs [26]. According to these high levels of acrylamide, crisps consumers in Kenya may be exposed to risks associated with acrylamide.

4. Conclusions and Recommendations

Acrylamide content of unbranded potato crisps are generally higher than those of the branded potato crisps. There exists a very weak positive relationship between the degree of redness and the acrylamide, however, no relationship between the degree of lightness and the acrylamide content exists. Ministry of Public Health and Kenya Bureau of Standards should take the lead in ensuring that the code of conduct to reduce acrylamide is adhered to. Regular monitoring of fried products and risk analysis should be carried out in the Kenyan markets and measures taken to reduce the levels of acrylamide in the commercial potato crisps.

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Statement of Competing Interests

The authors have no competing interests in the study.

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